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Early loss of herring gull clutches after egg-oiling

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Abstract Critical to the success of egg-oiling to control growth of bird populations is extension of the incubation period, thereby minimizing re-nesting attempts. Egg-oiling studies conducted with ring-billed (*Larus delawarensis*) and herring (*L. argentatus*) gulls generally have reported no evidence of abandonment of oiled clutches up to the expected hatching date (EHD). However, comparisons of clutch loss (assumed to be caused primarily by predation) up to EHD among control and treatment groups were not reported. Therefore, we evaluated early (oiling 21-27 days before EHD) and late (oiling 7-15 days before EHD) oiling protocols in a herring gull colony on Lake Erie, Erie County, Ohio. We observed marked differences ($P<0.001$) among treatments in number of nests producing chicks (90.0%, $n=100$, control; 20%, $n=100$, early oil; and 1%, n=100, late oil). Clutches in nests assigned to the 2 oil groups were more frequently ($P<0.001$) lost (6% control; 29% early; 38% late) to abandonment, storms, and predation up to EHD. Only 56% of oil-treatment clutches were incubated past EHD. Clutch loss (including nest abandonment) up to EHD did not differ ($P=0.346$) between nests in the early and late oil groups. Our data suggest that herring gulls were sensitive to oil and that nests were abandoned or clutches lost within the normal incubation period in numbers greater than expected under natural conditions. Thus, while effectiveness of egg-oiling to reduce recruitment in herring gull colonies is improved by oiling nests late in the incubation period, subsequent oil applications are recommended to account for late nests and re-nesting attempts.

Key words corn oil, egg-oiling, Herring gull, *Larus argentatus*, nest abandonment, population growth, reproductive control

Populations of bird species whose activities conflict with human activities have increased in North America and Europe (Hatch 1995, Belant 1997). Many avian species have adapted to habitats created by humans (e.g., agricultural fields, landfills, rooftops, airfields, and golf courses), causing a concurrent increase in conflicts (Blokpoel 1976; Dolbeer 1990; Blokpoel and Tessier 1992; Belant et al. 1993, 1995; Christens et al. 1995). Expanding gull (*Larus* spp.) populations, for example, have forced wildlife managers to consider population control measures to mitigate threats to agriculture, fisheries, other avian species, air traffic, and human health (Drury and Nisbet 1969, Blokpoel and Tessier 1992, Morris et al. 1992, Dolbeer et al. 1993, Belant 1997, Dolbeer 1998). Effective population management necessitates a thorough knowledge of the ecology of the species involved, as well as availability of proven, socially acceptable methodologies (Blokpoel and Tessier 1986, 1988).

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Egg-addling, comprising a variety of methodologies, may be more socially acceptable than killing adults or nestlings to control population growth in problem bird species. The objective of egg-addling is to reduce population growth by preventing reproduction. One method, egg-oiling, involves using oil-based products to asphyxiate eggs during incubation (Gross 1951, Thomas 1972). Success of an egg-oiling program depends on preventing hatching of oiled clutches and extending incubation to minimize re-nesting attempts (Gross 1951).

Early proponents of egg-oiling to control problem populations (Gross 1951, Drury and Nisbet 1969) contended that adults would continue to incubate oiled clutches beyond the normal incubation period. Recent studies involving oiling of ring-billed (*Larus delawarensis*) and herring (*L. argentatus*) gull nests (Blokpoel and Hamilton 1989, Morris and Siderius 1990, Christens and Blokpoel 1991, Pochop et al. 1998) support this contention, reporting no abandonment of oiled clutches during the normal incubation period. However, in studies of gulls where loss of oiled clutches (assumed to be caused primarily by predation) was observed prior to the expected hatching date (Blokpoel and Hamilton 1989, Morris and Siderius 1990, Christens and Blokpoel 1991), comparisons among treatment and control groups relative to timing and extent of clutch loss were not reported. Pochop et al. (1998) reported the percentage of oiled (2 groups) and control clutches that failed, but did not report whether oiled clutches were abandoned during the normal incubation period or incubated beyond the expected hatching date (EHD). Thus, in these studies the potential for more frequent loss of oiled than untreated clutches within the normal incubation period (which would increase the likelihood of re-nesting) was not evaluated. In contrast, Christens et al. (1995) reported that Canada geese (*Branta canadensis*) abandoned oiled clutches (2 groups) prior to EHD at significantly greater rates ($\bar{x}$=43.7%) than controls (16.1%).

Effectiveness of egg-oiling to extend incubation is best evaluated by contrasting the number of oiled clutches that produce ≥1 chick and number of oiled clutches lost (to abandonment or other factors) during the normal incubation period to the same statistics for clutches exposed only to natural mortality (a control group). The purpose of this study was to evaluate the effectiveness of early and late oiling of herring gull clutches (relative to stage of incubation) to extend incubation, thereby reducing the likelihood of re-nesting. Specific objectives of the study were to determine 1) number of eggs hatched/nest and 2) number of clutches lost (including abandonment) relative to EHD for control, early, and late oil groups.

Study area

We conducted this study on the south breakwall at Cedar Point Marina on Sandusky Bay, Lake Erie, in Erie County, Ohio (see Dolbeer et al. 1990, Figure 1). Approximately 50% of the breakwall consisted of riprap with a thin soil layer sustaining primarily herbaceous and low-growing woody vegetation. The remaining section of the breakwall comprised boulders and contained little or no vegetation. Although double-crested cormorants (*Phalacrocorax auritus*) roosted on the breakwall, the herring gull was the only colonial bird species nesting there.

Methods

We visited the colony on average every 3.7 (SD=1.2, n=21, range=2–8) days from 2 April to 19 June 1998. Between 2 and 23 April, we marked 300 nests (i.e., nests containing ≥1 egg) with numbered ceramic tiles. The first known clutch of the season was discovered and marked on 2 April. Upon marking, a nest was assigned randomly to 1 of 3 treatments (100 nests/treatment): 1) control, 2) oiling 21–27 days before EHD (early), and 3) oiling 7–15 days before EHD (late). Control clutches were not oiled. Three eggs are considered a complete clutch for herring gulls, and incubation ranges from 24 to 28 days (Bent 1963). Because herring gulls do not begin incubation in earnest until clutch completion (Tinbergen 1960), EHD was determined by adding 26 days to the predicted date of the laying of the last egg. For nests discovered prior to clutch completion, we assumed a 24-hour interval between eggs and calculated EHD relative to the predicted date for clutch completion. We monitored clutches in each treatment group relative to incubation or loss (see below) from the day of marking.

Using a plastic, hand-held spray bottle and corn oil (Pochop et al. 1998), we sprayed clutches until each egg was covered and the bowl of the nest saturated (also see Blokpoel and Hamilton 1989, Christens and Blokpoel 1991). We did not rotate individual eggs during oiling. Nests assigned to the early treatment were oiled upon discovery of the second or third egg. During the following visit, previously oiled 2-egg clutches were re-oiled if a third egg was present. Procedures involving herring gulls were approved by the National Wildlife Research Center Animal Care and Use Committee.

Table 1. Fate of herring gull nests in a colony on Sandusky Bay, Lake Erie, Erie County, Ohio that served as controls (no oil) or were subjected to egg-oiling early (21-27 days prior to the expected hatching date [EHD]) and late (7-15 days prior to EHD), April-June 1998.

Treatment	No. nests	Clutches lost up to EHD: Abandoned	Other[a]	Total	Clutches hatching ≥1 chick	Clutches incubated beyond EHD
Control	100[b]	0	6	6	90	4
Early oil	100	14	15	29	20	51
Late oil	100[c]	18	20	38	1	61

[a] Includes clutches assumed lost to predation and storms.

[b] One clutch was damaged by an observer, but was incubated beyond EHD.

[c] Nine clutches scheduled for late oiling were lost (3 abandoned, 6 other) prior to oiling.

We categorized final clutch status as either hatched (≥1 chick), abandoned, or other loss. An abandoned nest exhibited no evidence of predation (e.g., tracks near the nest, eggs punctured or broken from the narrow end), the nest bowl was often unkempt, and eggs were either left unincubated or found decaying outside the nest. We determined whether a clutch was incubated by touching the eggs and bowl of the nest (i.e., warm or cold). Clutch loss characterized as other included predation or storm loss and represented instances of complete clutch loss since the last visit to the colony, with no recovery of decaying eggs or remains near the nest. However, in some cases nest abandonment may have preceded clutch loss to predation or storms. Potential nest predators included crows (*Corvus brachyrhynchos*), raccoons (*Procyon lotor*), fox snakes (*Elaphe vulpina*), and snapping turtles (*Chelydra serpentina*).

We conducted 2 × 3 contingency table analyses (Conover 1980) to compare the number of clutches hatching ≥1 chick (versus those not hatching) among the 3 treatments. In the same fashion, we compared number of clutches lost, including nest abandonment and other loss (versus those not lost), up to EHD (i.e., ≤26 days) among treatments. Subsequent comparisons of the number of clutches lost between oil groups combined and controls were made using 2 × 2 contingency tables. Also, using the Student's *t*-test for unequal variances, we compared total incubation time between oil treatments for clutches incubated past EHD. Prior to tests involving the post-EHD clutches, we conducted tests for normality using PROC UNIVARIATE with the NORMAL option (SAS 1987). We made all statistical comparisons at $\alpha=0.05$.

Results

Clutch sizes among the 300 nests ranged from 1 to 4 eggs. We observed means of 2.9 (SD=0.4, n=100), 2.8 (SD=0.5, n=100), and 2.8 (SD=0.5, n=100) eggs/nest for control, early, and late treatment groups, respectively. The EHD across treatment and control groups ranged from 2 to 21 May ($\bar{x}$=14 May, SD=4.5 days, n=300). Oiling dates for clutches in the early group ranged from 10 to 27 April ($\bar{x}$=19 April, SD=4.3 days, n=100) and 20 April to 14 May ($\bar{x}$=1 May, SD=4.9 days, n=91) for clutches in the late group. Nine clutches in the late oil group were lost prior to oiling (Table 1). Hatching occurred first in the control group and was recorded on 4 May.

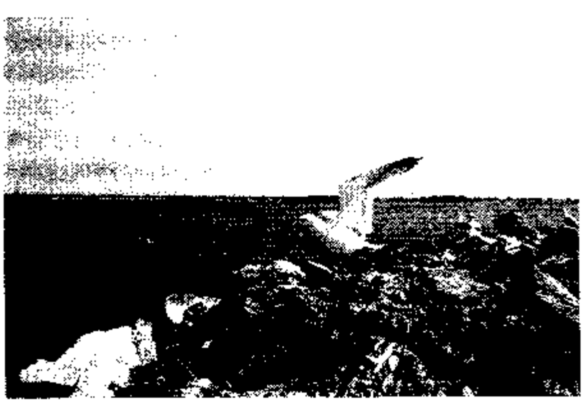
We noted differences ($\chi^2_2=188.5$, $P<0.001$) in number of clutches producing ≥1 chick/group (Table 1) and marked differences in mean hatching rate ($\bar{x}$ eggs/clutch) per group (control: $\bar{x}$=1.95, SD =0.95, n=99; early: $\bar{x}$=0.35, SD=0.76, n=100; and late: $\bar{x}$=0.01, SD=0.10, n=100). One clutch in the control group was damaged by an observer and not included in calculating hatching rate. Differences ($\chi^2_2=29.6$, $P<0.001$) also were observed among treatments in clutches lost up to EHD (Table 1), specifically the more frequent ($\chi^2_1=27.6$, $P<0.001$) loss of clutches in oil groups. Similarly, considering only nest abandonment up to EHD, nests in the early and late oil groups were ($\chi^2_1=8.4$, $P<0.001$) abandoned more frequently than controls (Table 1). However, clutch loss up to EHD (including nest abandonment) did not differ ($\chi^2_1=1.8$, $P=0.261$) between nests in the early and late oil groups.

Across treatments, estimated incubation time prior to clutch loss ranged from 1 to 66 days. Control clutches that did not hatch (n=10) were incubated on average 22.9 (SD = 16.4) days; unhatched clutches in the early (n=80) and late (n =99) groups (Table 1) were incubated on average 32.0 (SD=15.8) and 29.8 (SD=13.9) days, respectively. For oil clutches incubated past EHD, total incubation time did not differ ($t_{97}=1.68$, $P=0.10$) between those in the early ($\bar{x}=41.6$ days, SD=9.5) and late ($\bar{x}=38.8$ days, SD=7.9) groups. In summary, 112 of 200 clutches in oil groups were incubated 1-40 days past ($\bar{x}=14.1$ days, SE=8.7) EHD.

Discussion

Because management of wildlife populations is increasingly subject to public and political opinion, it is essential for wildlife managers to use sound methodologies based on objective data. For example, egg-oiling guidelines suggesting that avian species will continue to incubate oiled clutches until late in the reproductive cycle should be based on contrasts between number of oiled clutches lost and natural clutch loss. Without an understanding of species behavior in response to egg-oiling, the planning of an oiling program, relative to frequency and number of applications necessary, becomes speculative.

We found that oil applied to herring gull nests late, as opposed to early, in the incubation period was more effective in reducing hatching rate, similar to findings by Blokpoel and Hamilton (1989), Christens and Blokpoel (1991), and Pochop et al. (1998) for ring-billed gulls. However, in contrast to previous gull egg-oiling studies (Gross 1951, Blokpoel and Hamilton 1989, Morris and Siderius 1990, Christens and Blokpoel 1991, Blokpoel and Tessier 1992, Pochop et al. 1998), we observed abandonment of nests assigned to oil groups prior and up to EHD and marked differences in overall clutch loss among oil and control groups during the same period (Table 1). Further, only 56% of clutches assigned to oil treatments were incubated past EHD (Table 1).



Adult herring gull on the study site in Sandusky Bay, Erie County, Ohio. Photo by Bradley F. Blackwell.

Herring gull nest placement that was typical of nests composing the 3 treatment groups in the study. Photo by Bradley F. Blackwell.

Importantly, differences in our results compared to previous gull egg-oiling studies are most likely from our quantification of clutch loss in treatment and control nests through the normal incubation period, rather than marked differences in methods. For example, there is evidence that predation rates of oiled clutches (whether incubated or abandoned is not clear) may be greater than that of untreated clutches and that incubating adults in some species are sensitive to oiled eggs. Blokpoel and Hamilton (1989) noted that many ring-billed gull clutches (treated and untreated) were damaged or lost to predators or scavengers before, during, and after the EHD. Similarly, Christens and Blokpoel (1991), working with ring-billed and herring gulls in the operational component (i.e., involving the use of a backpack sprayer) of their study, reported that egg depredation prevented evaluation of the effectiveness of the experiment. Further, Morris and Siderius (1990) reported losses of control and oiled (with a light-grade petroleum oil) ring-billed gull eggs due to the discarding of rotten eggs by adults and the disappearance of others. In addition, the authors observed greater rates of preening and readjustment of nest material by a subsample of 15 pairs incubating treated eggs. Finally, Christens et al. (1995), who quantified clutch loss through the normal incubation period (for Canada geese), reported pre-EHD abandonment of clutches treated with white mineral oil.

Also, except for data analyses, the main methodological difference between our and prior studies is our use of corn oil on herring gull clutches. Although corn oil has been used on ring-billed gull eggs (Pochop et al. 1998), the study evaluated its effects on egg viability only. Further, relative to the method of oil application and clutch coverage, we followed methods used both by Blokpoel and Hamilton (1989) and Christens and Blokpoel (1991). Specifically, Christens and Blokpoel (1991), in the experimental component of their study, used a hand-held spray bottle and applied approximately 5 ml/clutch. Similarly, Pochop et al. (1998) used a hand-held spray bottle and applied ≥ 6 ml of oil/clutch.

Thus, in this study, while late oiling reduced egg viability, the difference in overall loss of oil treatment versus control clutches up to EHD, as well as the similarity in numbers of clutches lost between oil treatments (Table 1), is indicative that incubating herring gulls were sensitive to oil and that oil contributed to early clutch loss (due to predation or nest abandonment).

Management recommendations

Reproductive control methodologies for gulls are long-term management strategies that vary relative to species, setting of the colony (i.e., structure or ground), and whether inducement of colony abandonment is desired (e.g., via nest-and-egg removal, egg removal, nest-and-egg destruction, or egg destruction; see Ickes et al. 1998). The objective of an egg-oiling program is to reduce population growth (not necessarily induce colony abandonment) by preventing reproduction. In planning an egg-oiling program for gulls, one should be aware of age-related factors affecting asynchrony in nest initiation (see Tinbergen 1960) and consider the stage of incubation when an oil treatment is most effective in reducing hatching. For ring-billed gulls, Christens and Blokpoel (1991) recommended an initial oil application 20 days after the first completed clutch is observed and re-applications 12 and 24 days later. Based on our results, we recommend: 1) monitoring colonies relative to nest initiation, 2) application of the first oil treatment to all nests when the first clutch is within 7–15 days of EHD, and 3) repeated visits on 3-week intervals through June to insure the inclusion of late nests and re-nesting attempts.

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Literature cited

Belant, J. L. 1997. Gulls in urban environments: landscape-level management to reduce conflict. Landscape and Urban Planning 38:245–258.

Belant, J. L., T. W. Seamans, S. W. Gabrey, and R. A. Dolbeer. 1995. Abundance of gulls and other birds at landfills in Northern Ohio. American Midland Naturalist 134:30–40.

Belant, J. L., T. W. Seamans, S. W. Gabrey, and S. K. Ickes. 1993. Importance of landfills to nesting herring gulls. Condor 95:817–830.

Bent, A. C. 1963. Life histories of North American gulls and terns. General Publishing Company, Limited, Toronto, Ontario, Canada.

Blokpoel, H. 1976. Bird hazards to aircraft. Clarke, Irwin and Company Limited in association with the Canadian Wildlife Service, Environment Canada, and the Publishing Centre, Supply and Services Canada, Ottawa, Ontario, Canada.

Blokpoel, H., and R. M. G. Hamilton. 1989. Effects of applying white mineral oil to chicken and gull eggs. Wildlife Society Bulletin 17:435–441.

Blokpoel, H., and G. D. Tessier. 1986. The ring-billed gull in Ontario: a review of a new problem species. Canadian Wildlife Service, Occasional Paper 57.

Blokpoel, H., and G. D. Tessier. 1988. Learning to live with nature: a commendable philosophy with practical limitations. Auk 105:396–397.

Blokpoel, H., and G. D. Tessier. 1992. Control of ring-billed and herring gulls nesting at urban and industrial sites in Ontario, 1987–1990. Proceedings of the Eastern Wildlife Damage Control Conference 5:51–57.

Christens, E., and H. Blokpoel. 1991. Operational spraying of white mineral oil to prevent hatching of gull eggs. Wildlife Society Bulletin 19:423–430.

Christens, E., H. Blokpoel, G. Rason, and S. W. D. Jarvie. 1995. Spraying white mineral oil on Canada goose eggs to prevent hatching. Wildlife Society Bulletin 23:228–230.

Conover, W. J. 1980. Practical nonparametric statistics, second edition. John Wiley and Sons, New York, New York, USA.

Dolbeer, R. A. 1990. Ornithology and integrated pest management: red-winged blackbirds *Agelaius phoeniceus* and corn. Ibis 132:309–322.

Dolbeer, R. A. 1998. Evaluation of shooting and falconry to reduce bird strikes with aircraft at John F. Kennedy International Airport. International Bird Strike Committee 24:145–158.

Dolbeer, R. A., J. L. Belant, J. L. Sillings. 1993. Shooting gulls reduces strikes with aircraft at John F. Kennedy International Airport. Wildlife Society Bulletin 21:442–450.

Dolbeer, R. A., P. P. Woronecki, T. W. Seamans, B. N. Buckingham, and E. C. Cleary. 1990. Herring gulls, *Larus argentatus*, nesting on Sandusky Bay, Lake Erie, 1989. Ohio Journal of Science 90:87–89.

Drury, W. W., and I. C. T. Nisbet. 1969. Strategy of management of a natural population: the herring gull in New England. Pages 443–453 *in* Proceedings of the World Conference on Bird Hazards to Aircraft, 2-5 September 1969, Natural Resources Council Kingston, Ontario, Canada.

Gross, A. 1951. The herring gull-cormorant control project. Proceedings of the International Ornithological Congress 10:532-536.

Hatch, J. J. 1995. Changing populations of double-crested cormorants. Colonial Waterbirds 18 (Special Publication 1):8-24.

Ickes, S. K., J. L. Belant, and R. A. Dolbeer. 1998. Nest disturbance techniques to control nesting by gulls. Wildlife Society Bulletin 26:270-273.

Morris, R. D., H. Blokpoel, and G. D. Tessier. 1992. Management efforts for the conservation of common tern *Sterna hirundo* colonies in the Great Lakes: two case histories. Biological Conservation 60:1-8.

Morris, R. D., and J. Siderius. 1990. A treatment for prevention of hatching in field-incubated ring-billed gull eggs. Journal of Wildlife Management 54:124-130.

Pochop P. A., J. L. Cummings, C. A. Yoder, and J. E. Steuber. 1998. Comparison of white mineral oil and corn oil to reduce hatchability in ring-billed gull eggs. Proceedings of the Vertebrate Pest Conference 18:411-413.

SAS. 1987. SAS System for elementary statistical analysis. SAS Institute Inc., Cary, North Carolina, USA.

Thomas, G. J. 1972. A review of gull damage and management methods at nature reserves. Biological Conservation 4:117-127.

Tinbergen, N. 1960. The herring gull's world—a study of the social behavior of birds. Harper Torchbooks, Harper & Row, New York, New York, USA.

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